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# SEMI-ANNUAL TECHNICAL REPORT, 1 APRIL-30 SEPTEMBER 73
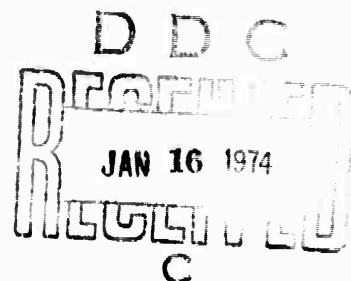
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SEMIANNUAL TECHNICAL REPORT OF

THE CENTER FOR ADVANCED COMPUTATION

April 1, 1973 - September 30, 1973


Center for Advanced Computation
University of Illinois at Urbana-Champaign
Urbana, Illinois 61801

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CENTER FOR ADVANCED COMPUTATION

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This is a progress report on APPA contract DAHC04-72-C-0001, entitled, "ILLIAC IV Applications Research at the Center for Advanced Computation, University of Illinois at Urbana-Champaign." During this period there was research in the following areas:

1.  Development of numerical techniques suitable for parallel processing in the areas of:
    a) Linear programming
    b) Algebraic eigenvalue
    c) Approximation of functions

2.  ILLIAC IV multispectral image processing
3.  Enhancements to the PEESPOL compiler
4.  Network Terminal Systems project
5.  Distributed computational systems of heterogeneous computers

# 1. APPLIED MATHEMATICS GROUP

## 1.1 Linear Programming

The Linear Programming system has been transferred from the simulator to the ILLIAC IV and developed to the point where a small program has been successfully run. This incorporates certain improvements to speed up the algorithm as outlined in a revised document [1]. This document also outlines the numerical calculations necessary to permit an out-of-core implementation for problems too large for the main memory. Some refinements are required, and much remains to be done in the input-output routines so that user programs may be run.

The implementation of the matrix generator language is close to completion; although this has been delayed because of shortage of personnel, it is hoped to have it completed and documented shortly.

## 1.2 The Algebraic Eigenvalue Problem

Studies for efficient parallel algorithms for finding the leading eigenvalues and vectors of large (and sparse) real symmetric matrices have been completed. A new algorithm that is suitable for a parallel machine is now being developed for finding the eigenvalues in any given interval [a,b] and the corresponding eigenvectors.

A modification of the QZ algorithm [2] for the eigenvalue problem $Ax=\lambda Bx$ for real symmetric A and B, with B being an ill-conditioned positive-definite matrix, has been developed and tested.

## 1.3 Approximation of Functions

The Applied Mathematics Group had previously made a study of methods of simultaneously fitting sets of exponential decay curves with a common decay constant [3,4]. The next step was to extend the work to situations in which the curves to be analyzed consist of the superposition of two or more decay curves. As a preliminary to this, a good algorithm for fitting a single curve by a sum of exponentials was needed. We have developed an algorithm to

do this by a method which is a combination of "differential corrections" and linear programming. The algorithm has been implemented (in Fortran) and tested. It seems to work well but is, as expected, slower than a Remez-type algorithm for the case of a single-term exponential approximation. A detailed report is in preparation.

In another line of work, results from a previous theoretical study [7] were found useful in verifying an error estimate in numerical linear algebra [6]. A report on this is available [5].

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7.  F. H. Kaufman, Jr. and G. G. Belford, "A Generalization of the Varisolvency and Unisolvency Properties," Journal of Approximation Theory, 7, pp. 21-35, 1973.

## 2. ILLIAC IV MULTISPECTRAL IMAGE PROCESSING

### 2.1 Introduction

In support of the earth resources monitoring objectives of the
ERTS/EROS programs of NASA and USGS, staff of the Center for Advanced
Computation is now completing development of an ILLIAC IV multispectral
image analysis system for digital interpretation of large quantities of
ERTS satellite multispectral scanner (MSS) imagery. The complete system
has been designed and implemented to exploit the full capabilities of
(1) the ILLIAC IV for image processing calculations; (2) the UNICON Data
Computer of the ILLIAC IV complex for storage and retrieval of numerous
multispectral images; (3) the time-sharing PDP-10 processors of the
ILLIAC IV complex for interactive image analysis; (4) the ARPA Network for
decentralized access to the system; and (5) the Center's PDP-11 ANTS system
for CAC image analysis research.

### 2.2 Data Management Systems

The level-one system now operational employs PDP-10 data management
software resident on ARPA Network PDP-10 computers at I.S.I. and Case
Western Reserve. PDP-10 ERTS data management software allows interactive
tape retrieval and display of specific ERTS data windows and transfer via
the network of these data files to NASA/Ames for ILLIAC IV interpretation.
The PDP-10 software also includes Fortran procedures for small-scale
image interpretation, thus permitting interactive trial image interpreta-
tions prior to ILLIAC IV batch calculations. An ERTS data management
system has been designed and is now being implemented using the UNICON
Data Computer at NASA/Ames. The availability of the Data Computer at Ames
for ERTS data management by December will greatly facilitate large-scale
ILLIAC IV interpretations.

## 2.3 ILLIAC IV Calculations

Multivariate cluster analysis and statistical classification pattern recognition algorithms have been developed in ASK for ILLIAC IV interpretation of ERTS MSS imagery. ASK simulation timings for these two algorithms indicate that the ILLIAC IV will be two orders of magnitude more cost-effective than the IBM 360/67 for comparable processing. The statistical classification algorithm is now being executed on the ILLIAC IV itself in support of the Center's research in this area.

## 2.4 Graphical Displays

Graphics systems have been developed for display of raw and interpreted ERTS MSS data on numerous output devices at the Center including T.I. terminals, line printers, the Computek and Imlac CRT's, and the Zeta plotter. Color Polaroid prints can be composed via color filtering of successive monochromatic Imlac displays. Emphasis is now being placed on the development of software for plotting interpreted data maps equivalent with respect to scale, area, and projection to USGS topographic maps of the 7-1/2', 15', and $1^{o}$ x $2^{o}$ quadrangle series.

## 3. NETWORK TERMINAL SYSTEMS PROJECT

### 3.1 ARPA Network Terminal System (ANTS) Development

Early this year, ARPA-IPT suggested that the Center hold an ANTS Users Group Meeting. An open invitation was extended to anyone interested in the status of ANTS, MARK II design and implementation. About forty people, representing twenty-five institutions, visited the Urbana campus on April 29 - May 1, 1973. A presentation on the design of MARK II was given, and discussions were held concerning the intentions of the University of Illinois to create an affiliated development corporation which would continue development as well as distribute and support ANTS.

At the time of the meeting, it was expected that the first operational version of ANTS, MARK II (supporting only the TELNET protocol) would be available by early July. Several problems were encountered which delayed this by four months. Completion of system design required three months rather than the four to six weeks expected in April. Hardware problems with the UCSD B6700 and the UCSD and UI IMPS seriously hampered progress -- we estimate a loss of over a month. Delivery of the PDP-11/50 was two months later than expected, thereby requiring use of the PDP-11/20 for both development and operations. Another week was lost with PDP-11/20 hardware problems. An additional few weeks were lost in late summer when vacations were taken. The result is that system coding was not completed at the end of this reporting period. Completion of coding is expected in October with an operational version of ANTS, MARK II (supporting the TELNET protocol) in November. Following this, the file transfer protocol (FTP) and remote job entry protocol (NETRJE) will be implemented, along with various device drivers for Center peripherals. Further development objectives and priorities will be established in cooperation with the recently created ANTS Steering Committee (ASC).

The ASC was created by ARPA-IPT in September to represent the ARPA ANTS user community's interest in future development of ANTS. Members of the ASC are Dave Crocker (UCLA), Tom Boyton (USC-ISI), Ken Pogran (MIT),

and Jerry Burchfiel (BBN). Initial discussions with the ASC have produced a tentative list of ANTS general specifications:

1. Individual systems will be tailored by Sysgens, according to:

   a) Hardware

      (1) Amount of core
      (2) Presence of secondary (swapping) storage
      (3) Number and type of peripherals
      (4) Number and type of terminals

   b) ANTS Software

      (1) What ANTS modules desired (partial list of available modules):

          (a) Line drivers for standard DEC-11 peripherals
          (b) NCP
          (c) Basic vs. extended (with options) TELNET
          (d) Basic vs. full FTP (server)
          (e) Basic vs. full RJE (server)
          (f) FTP (user)
          (g) RJE (user)
          (h) Netgraphics (different levels)
          (i) Basic vs. fancy terminal support (e.g., with command completion/recognition, formatting simulation, etc.)
          (j) Accounting/authorization
          (k) User-defined commands words and functions
          (l) System monitor to call larger host, for debugging/diagnostics

      (2) What modules to be locked in core vs. swapped, if disk available

2. User-level features available:

   a) TIP-emulation, for the traveler
   b) Full-duplex command completion/recognition (probably)
   c) User-defineable procedures and command set
   d) Rich terminal support features:

      (1) Character/line/image modes
      (2) Line-mode input editing
      (3) Page-size and tab simulation
      (4) Upper/lower, upper only, or convert to lower case
      (5) Line-feed inserted after carriage return
      (6) Single-command access to popular Net functions
      (7) Variable timing delay for <FF>, <CR>, <LF>
      (8) Print/discard output to terminal
      (9) Multiple connections per terminal
      (10) Terminal status and reset parameters commands
      (11) Range of terminals "known"

e) Generally friendly features:

    (1) Variety of ways to specify hosts (synonyms or #)
    (2) System status including user list
    (3) Escape-to-command character not needed if no connection opened
    (4) CONNECT command defaulted, so that user need only enter hostname/number
    (5) Recording of terminal session, if port (and core) available

3. PEESPOL

    a) Fix PEESPOL compiler to generate PAL
    b) Have PEESPOL modules separately compilable
    c) Have ANTS highly plugable, allowing mix of languages

It is expected that most of the above features will prove to be desirable. Discussions will be held to refine the list and develop implementation priorities. An ANTS Users Group Meeting will be scheduled for January or February to discuss the state of development and implementation schedules.

At the beginning of this six month reporting period, two staff members were assigned the responsibility for assisting Gary Grossman in implementation of ANTS, MARK II. In September, three additional staff began their education in ANTS and PEESPOL and are expected to contribute to system enhancements during the next quarter.

During the reporting period a paper entitled "A New Approach to Network Access Computer System Design," was prepared by W. J. Bouknight, G. Grossman, and D. Grothe for presentation at the Third Data Communications Symposium, 13-15 November 1973. This paper presents the design philosophy of ANTS, MARK II.

### 3.2 New ANTS Systems

During this period, contracts were negotiated and signed with NASA-Ames Research Center and Lincoln Laboratory to provide and support customized versions of the ANTS system.

The NASA-Ames system includes an extended graphics display capability. The system will include a PDP-11/45 system with 32K words memory, VERSATEC printer/plotter, mag tapes, disk packs, a distant Host interface to the network, and a PDP-11/10 satellite I/O processor. The 11/10 will serve to interface Ames' current set of graphics displays to the 11/45 and thence to network protocols. In addition, the 11/10 will interface to the Ames IBM 1800 providing its peripherals with network access. Scheduled for later implementation will be an advanced design graphics display system of the Vector General or E and S class.

The Lincoln Labs system is comprised of a PDP-11/40, 24K words core, disk packs, VERSATEC printer/plotter, GT-40 display system, and a very-distant-Host interface to the network. The GT-40 system will be used to display seismic data stored on the network and retrieved by ANTS. Additional display support and improved file management facilities in ANTS are scheduled for future implementation.

## 3.3 Enhancements to the PEESPOL Compiler

PEESPOL, an acronym for PDP-11 Executive System Program Oriented Language, was designed and implemented for the purpose of creating a high level implementation language for PDP-11 system programming. PEESPOL "looks like" ALGOL (i.e., it is a block structured language with storage allocated via declarations, etc.). PEESPOL also handles PDP-11 Assembly Language (PAL) statements and contains a rather powerful macrogenerator facility. The PEESPOL compiler runs on the Burroughs B6700 system, accepts input in card-image form, and creates a disk file containing the PDP-11 system object code. PEESPOL has been in use for the past two years for implementation of ANTS, MARK I and development of ANTS, MARK II.

During the reporting period, the following tasks were performed:

(1) Correction of a number of bugs which had been discovered in the compiler,

(2) Extension of the language by the inclusion of a number of additional language constructs and

(3) Updating of the PEESPOL Reference Manual to a preliminary form for internal use.

The additions and enhancements to the language have enabled the ANTS System Programming group to more efficiently program the ANTS, MARK II system. Changes also permit compiling versions of ANTS for use on the PDP-11/40 and 11/45 as well as the PDP-11/20.

In September, Marty Ozga joined Dave Grothe to work on future development of PEESPOL. During the next quarter, papers will be prepared for the 1974 NCC proceedings describing PEESPOL and its use as a system implementation language. The preliminary version of a PEESPOL Reference Manual will be developed to a state for external distribution.

## 3.4 ARPA Network Usage

During the reporting period, network usage was heavy on several systems -- especially the UCSD B6700, the UCLA 360/91, the MIT-Multics system, the USC-ISI PDP-10 TENEX systems. Activities began which pertain to use of and access to the ILLIAC IV complex at Ames. (Use of this system is described in other sections of this report.) The NTS group provides local system support and network consulting for University of Illinois users of these systems. A new version of the Network Users Handbook was released. The Handbook introduces new network users to available network facilities.

## 3.5 Graphics Support for Center Projects

The Fancy ARPA Network Graphics System (FANGS) was completed at the UCSD B6700 system. This package provides a sophisticated interactive system for graphical analysis and displaying user design imagery. Documentation for this system is forthcoming. Capabilities exist in FANGS for transfer ing graphical images to the Gould plotter, Computek graphics scope, Imlac display and the newly acquired Zeta drum plotter system.

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## 3.6 Hardware Acquisition

During the reporting period, the PDP-11 Model 50 computer system was delivered and installed at the Center. An additional ARPANET interface was acquired for this system so that the Center now has both a production network access system (PDP-11/20) and a development system (PDP-11/50).

Additionally, the Zeta drum plotter procured by the Laboratory for Atmospheric Research support was delivered and placed into operation. This new plotter provides plotting of imagery up to thirty-six inches in width with the selection of one of four pens.

Additionally, two Diablo terminals were ordered to provide the Center with advanced documentation quality printout devices. A new line printer was ordered to serve as a backup to the Gould electrostatic printer/plotter.

## 3 7 Laboratory for Atmospheric Research Support

Support for the University of Illinois' Laboratory for Atmospheric Research (LAR) continued with the development of graphics packages at several network sites for displaying LAR's simulation results in graphical form on CAC equipment. Basic graphics display software was written on the UCLA IBM 360/91 and the USC-ISI PDP-10. Graphical imagery can now be returned to the Center for display on the Gould, Imlac, Computek, and Zeta plotter. Further efforts in the next reporting period will be involved in extending and improving the efficiency of these graphical support services.

W. J. Bouknight, "IMP Interface Manual," NTS Document no. 2, University of Illinois at Urbana-Champaign, 6 June 1973.

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M. S. Sher, "Experience in Networking -- A Case Study," NTS Document no. 4, University of Illinois at Urbana-Champaign, July 1973.  (Published in the fall 1973 issue of EDUCOM Bulletin; revised version to appear in Datamation.)

# 4. DISTRIBUTED SYSTEM GROUP

The Distributed System Group was formed during this period to conduct research in distributed computational systems of heterogeneous computers. A single software environment will be built that spans several computers on the ARPA Network. The composite environment should have cost, response, and reliability parameters which are significantly better than can be provided at any single computational site.

The target system will be a large data base system for use in the areas of large scale modeling, such as, input/output economic analysis, quadratic modeling, and statistical analyses. The target system will demonstrate distributed processing of massive computational jobs and large, geographically distributed data bases. The system should be able to grow and include unique facilities available on the ARPA network such as the ILLIAC IV and the Data Computer.

## 4.1 PL/I Compatibility

The initial software will be written in PL/I. A single language was chosen at this early, proof-of-concept phase to reduce the software development effort. PL/I is acceptable because it has powerful data and control features and it is available on the Burroughs B6700 at San Diego, Honeywell Multics at MIT, and several IBM 360/370 facilities around the network (particularly the 360/91 at UCLA/CCN). Future coupling of the ILLIAC IV, the Data Computer, and other unique facilities will require multilanguage software.

By using a compatible subset of PL/I that will work on Burroughs, Honeywell, and IBM facilities, we hope to achieve a highly transportable system. Should one module of the distributed system located at one node on the ARPA network fail, it will be feasible to reinitiate the module on a back-up facility, using different hardware at another mode. The bulk of the Distributed System Group effort through December 1973 will be on the identification of a suitable subset of PL/I which may be compatibly

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16. DISTRIBUTION STATEMENT (of this Report)

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

None

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Applied Mathematics
ILLIAC IV Multispectral Image Processing
Network Terminal Systems
Distributed Computer Systems

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

See the Report Summary on page 1 within the report itself.

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used on Honeywell, Burroughs, and IBM equipment. Serious deficiencies in the compatibility of multitasking and compile time facilities have already been identified. More subtle discrepancies in data conversion and data declaration have also been identified.

It is expected that the basic work of the PL/I project and the identification of the compatible subset will be completed by December 1973. A report on the compatible PL/I subset will be prepared in the first quarter of 1974.

## 4.2  Multimachine Education

An education effort has been undertaken to improve the fluency of Distributed System Group programmers in the use of Multics, the B6700, TSO on OS/360, and TSS on the 360/67. Seminars and formal training sessions by vendors have been presented to the group. Each group member is responsible for two areas of the PL/I project. This requires him to become an expert on and document the compatibility of PL/I facilities in those areas on IBM, Honeywell, and Burroughs equipment. This is an effective reinforcement mechanism with which to follow the formal training sessions and seminars.

## 4.3  Network Protocols

An effort to define process control and data transfer protocols that will live on top of standard ARPA network protocols is continuing. Message encrypting and other protection facilities are being studied to insure the privacy of data transferred across the network. Protocol development will be minimal until the PL/I compatibility project is completed.

# 5.  ADMINISTRATION AND FISCAL STATUS

## 5.1  Administration

During this report period, Professor Daniel L. Slotnick resigned as director of the Center for Advanced Computation.  Professor Hugh Folk is acting director.

## 5.2  Fiscal Status

Actual expenditures through 30 September 1973:  $532,339.

Expenditures for the six month period covered in this report (1 April 1973 - 30 September 1973):

| | |
|---|---|
| April | $ 62,859 |
| May | 92,917 |
| June | 89.397 |
| July | 74,747 |
| August | 133,638 |
| September | 78,781 |
| | $532,339 |

Expenditures and obligations outstanding through 30 September 1973: $3,549,559.

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